Indian J. Phys. **48**, 1052–1053 (1974)

A note on the p-d scattering

M. DHARA

Indian Association for the Cultivation of Science, Calcutta 700032

(*Received* 24 *July* 1974)

In the previous paper* (Dhara 1974), we have shown that the binding energy of ^{3}He is easily estimated by the Faddeev techniques with non-local separable nuclear interaction. In continuation of paper I, we have estimated here the phase-shifts of the p–d scattering for the $l = 0$.

We have already discussed the Faddeev T-matrices for the p–d scattering in eq. (38) of paper I as

$$X_i(E_i', E) = \sum_i U_i(E_i', E) - \sum_{i\neq j} Z_{ij}(E_i', E)U_j(E_i', E) +$$

$$2\sum_{i\neq j}\int_0^\infty Z_{ij}(E_i', E_i'')Z_{ji}(E_i', E_i'')X_i(E_i'' E)\,\mathrm{d}E_i''(i, j = 1, 2, 3), \quad \dots \quad (1)$$

where $Z_{ij} = 0$ if $i = j$.

Replacing the momentum $\boldsymbol{k}$ by the energy variable E with the relations

$$|\boldsymbol{k}_1| = (mE_1)^{\frac{1}{2}} \quad \text{and} \quad |\boldsymbol{k}_3| = (2mE_1)^{\frac{1}{2}}$$

the matrices $t_0^c(\boldsymbol{k}_3, \boldsymbol{k}_3' : z)$ and $t_0(\boldsymbol{k}_1, \boldsymbol{k}_1'; z)$ become

$$\begin{aligned} t_0^c(\boldsymbol{k}_3, \boldsymbol{k}_3' : z) &= t_0^c\,(E_1, E_1' : z) \\ &= (\beta_0^2+2mE_1)^{-1}(\beta_0^2+2mE_1')^{-1}(4\pi^2\mu^2e^4/m^2E_1E'_1)^{\frac{1}{2}} \\ &\times[\exp(2\pi\mu e^2/(2mE_1)^{\frac{1}{2}})-1]^{-\frac{1}{2}}[\exp(2\pi\mu e^2/(2mE_1')^{\frac{1}{2}})-1]^{-\frac{1}{2}} \\ &\times\exp[(2\mu e^2/(2mE_1)^{\frac{1}{2}}\tan^{-1}((2mE_1)^{\frac{1}{2}}\beta_0^{-1})]\exp[(2\mu e^2/(2mE'_1)^{\frac{1}{2}} \\ &\times\tan^{-1}c(2mE'_1)^{\frac{1}{2}}\beta_0^{-1})][\lambda_{pp}^{-1}-(2\pi^2)^{-1}\int_0^\infty(m^3E'_1)^{\frac{1}{2}}(2\pi\mu e^2/(2mE'_1)^{\frac{1}{2}}) \\ &\times\exp[2\mu e^2/(2mE'_1)^{\frac{1}{2}}\tan^{-1}((2mE'_1)^{\frac{1}{2}}\beta_0^{-1})](\beta_0^2+2mE'_1)^{-2} \\ &\times(z-2mE'_1)^{-1}[\exp(2\pi\mu e^2/(2mE'_1)^{\frac{1}{2}})-1]^{-1}\mathrm{d}E'_1]^{-1}, \end{aligned} \quad \dots \quad (2)$$

---

* Cited as paper I hereafter.

and

$$t_0(\boldsymbol{k}_1, \boldsymbol{k}'_1; z) = t_0(E_1, E'_1; z)$$
$$= (\beta_0^2 + mE_1/2)^{-1}(\beta_0^2 + mE'_1/2)^{-1}[\lambda_{np}^{-1} - (2\pi^2)^{-1}$$
$$\times \int_0^\infty (m^3E'_1/32)^{\frac{1}{2}}(\beta_0^2 + mE'_1/2)^{-2}(z - mE'_1/2)^{-1}dE'_1]^{-1}. \quad \ldots \quad (3)$$

The Faddeev T-matrices were estimated at different energy levels viz., 5, 8, 10 and 15 MeV for the p–d elastic scattering. Using the relation (Lovelace 1964)

$$t(k, k; k^2) = -\tan \delta/2\pi^2 k,$$

the phase-shifts were estimated from these matrices for the $l = 0$. The values of the parameters are taken same as in paper I. Our results and those of others are shown in table 1.

Table 1. The values of the phase-shifts at different energy levels

Energy (MeV)	Phase-shifts (radians)		
	Ours	BHM*	CG**
4.20		−1.15	
5.00	−1.17		
5.18			−1.38
7.40		−1.52	
8.00	−1.24		
9.66			−1.77
10.00	−1.31		
11.50		−1.82	
15.00	−1.35		

* Buckingham *et al* (1952), ** Christian *et al* (1953)

BHM's theory was includes $l = 0,1,2$ whereas ours only $l = 0$. This probably explains the small energy dependence of our $l = 0$ phase-shifts are discrepancy at higher energies. CG determined their phase-shifts $l = 0$ from the experimental differential cross-sections and the phase-shifts for $l \geqslant 1$ calculated in Born approximation.

It is hoped that the results of this note will be useful in answering the question of whether separable potentials have meaning in situations other than on-shell two-particle scattering as well as the Faddeev equations are applicable to the three-body problems.

The author wishes to thank Dr. S. Hochberg, Imperial College, London for many enlighting discussions and Professor S. D. Chatterjee for his interest in this problem.

References

Buckingham R. A., Hubbard S. J. & Massey H. S. W. 1952 *Proc. Roy. Soc.* **A211**, 183.
Christian R. S. & Gammel J. L. 1953 *Phys. Rev.* **91**, 100.
Dhara M. 1974 *Indian J. Phys.* **48**, 690.
Lovelace C. 1964 *Phys. Rev.* **135**, B1225.